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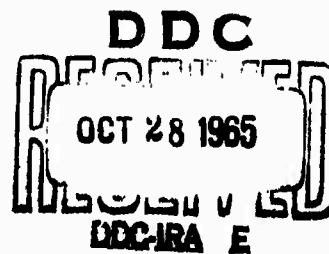
THE PERKIN-ELMER CORPORATION

Absorption of Light in Gases

Fourth Quarterly Letter Report
through 30 September 1965

Submitted by

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to the

OFFICE OF NAVAL RESEARCH

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THE PERKIN-ELMER CORPORATION
E-O RESEARCH DEPARTMENT

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1. General Status of Project

As of submission of this report, all of the necessary equipment is constructed to complete the absorption measurements with a ruby beam in air samples from 6942 - 6943 Å.

The work is now at the stage of attempting to get good data. Preliminary experiments with a piezo-electric ceramic microphone indicate that the sensitivity and bandwidth of this type of microphone is inadequate to detect the H₂O band at 6942.15 Å. This is as expected, based on the calculated sensitivity. It confirms that there is no anomalously large absorption, and that the sensitivity of the collodion membrane microphone will be required.

All of the subsystems of the experiment have been successfully operated separately, - all but the new force-balance collodion microphone have been operated together to get the preliminary negative result described. Work during the past quarter on these subsystems is described below.

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Pulsed Laser

Difficulties encountered with reproducibility of the ruby laser shots were traced to loose parts and dirt in the pumping head and corrected. It now operates well making 20 millijoules, usually single pulse, single mode with $\pm 10\%$ reproducibility, at 15°C and with 5760 joules input to the flash lamp.

Temperature scanning from -10°C to room temperature has been achieved.

Wavelength Calibration

The Fabry-Perot etalon with 5 mm spacer has proved to be quite stable. The method we have adopted for frequency calibration of each laser pulse is as follows.

On each shot, the ruby beam leaving the tank is passed through lenses to spread the beam, then through a diffusing screen to uniformly backlight the etalon, then to the etalon, and into a camera with a Polaroid back. The camera, etalon, and lenses are shown in Figure 1.

A Fabry-Perot ring pattern is produced with ring-to-ring spacing representing frequency spacing of 1.00 cm^{-1} , or 1.44\AA . The finesse of the ring fringes is about 20. With a measuring engine, the center of the fringes can be located about $1/10$ of their width with ease. This permits resolution of $\pm 0.005\text{ cm}^{-1}$ (0.007\AA), which is better than adequate for measurements of samples at one atmosphere pressure.

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The drift in spacing of the etalon is standardized out by exposing on each photo a similar ring pattern from the stabilized neon laser displaced from the ruby pattern. The neon laser is kept at the center of its 6328Å doppler band by manual adjustment. Figure 2 shows a typical calibration photo with neon fringes at right and ruby ring at left.

The method does have an ambiguity of 1 cm^{-1} in determining the ruby frequency, but we can eliminate this simply by knowing the ruby temperature.

The method does not identify the difference of orders of interference in which 6328Å and 6942Å rings are seen. Neither does it account for differences in phase shift on reflection at the two wavelengths. The phase shift is sure to be large with dielectric coatings on the etalons. Therefore, it does not identify the absolute wavelengths.

We expect to do this later using R_1 line fluorescence from a piece of ruby cooled to liquid nitrogen temperature as an absolute frequency transfer standard between the etalon and calibrated grating spectrograph.

Acoustic Sampling Tank and Noise Measurement

The acoustic tank complete with parabolic cylinder and paraboloid sound mirrors has been assembled, sealed and evacuated to test ability to transfer pure gas samples into it. There are minor leaks, but a pressure of 8×10^{-2} mm Hg or less can be maintained, which is adequate. The sound mirrors are shown in Figures 3 and 4. A drawing of the assembled tank showing the acoustic path is shown in Figure 5. An antechamber containing the membrane microphone is attached over the sound focus.

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Experiments using a General Radio sound intensity meter with the microphone enclosed in the tank show that we can reach a sound level of +35 db in a bandwidth from about .5Kcps to 10Kcps (Acoustic Weighting "A"). This sound level is near the noise level of the sound metering system. The noise inside the tank drops off rapidly with increasing frequency as expected. It seems reasonable to expect that in the 100 - 300 KC frequency range, the room noise will not be a problem.

Figure 6 shows a trace of the acoustic response in a complete experiment, using the G-R crystal microphone as a receiver.

The signal, up to the 5th millisecond, is apparently the sound meter's electronic noise level. Then, the response to the sound of the flash-lamp can be seen. However, no identifiable acoustic signals arrive at the proper time (1.5 milliseconds), so that we as yet cannot see the response to the H_2O band. Using a 10 Kcps bandwidth device to detect a 100 Kcps Gaussian pulse will result in a loss of at least 27db. Hence, the acoustic signal is not greater than 62 db, indicating an absorption of less than 10^{-6} cm^{-1} .

The Force Balance Microphone

An improved method of extending the dynamic range of the membrane microphone was breadboarded in which the fringe motion caused by motion of the membrane generates an error signal which is amplified and applied to the membrane. This is situated in a strong electric field produced by two

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fine wire grids. The restoring force of the electric field nulls the acoustic pressure.

Figure 7 shows a new unit of the microphone built with the knowledge gained from the earlier breadboards. This unit has an improved optical system and finer grid wires. At this time it has not been tested, but results with the breadboard indicate that it should have adequate sensitivity.

Calibration

After consideration of many methods of absolute calibration of the sensitivity of the sound receiver, we believe that the best method is to use the known geometry of the force balance microphone and obtain its absolute sensitivity by calculation of the restoring force. Absolute accuracy to a factor of 3 can be assured by this approach, which is adequate for the initial measurement.

Plans for Next Period

Data on the absorption spectrum of H_2O in air from 6942 to 6943A^o will be obtained in the next period.

A final report critically evaluating the acoustic method will be prepared and a recommendation for follow-on work will be submitted.

Second Semiannual Technical Summary Report

We are planning to submit the Final Report in lieu of a second Semiannual Technical Summary Report, because if we issue a Semiannual

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Report there will only be one month of additional work to be described in the final report. Thus, the additional expense and time spent for a second Semiannual Report do not appear to be justified.

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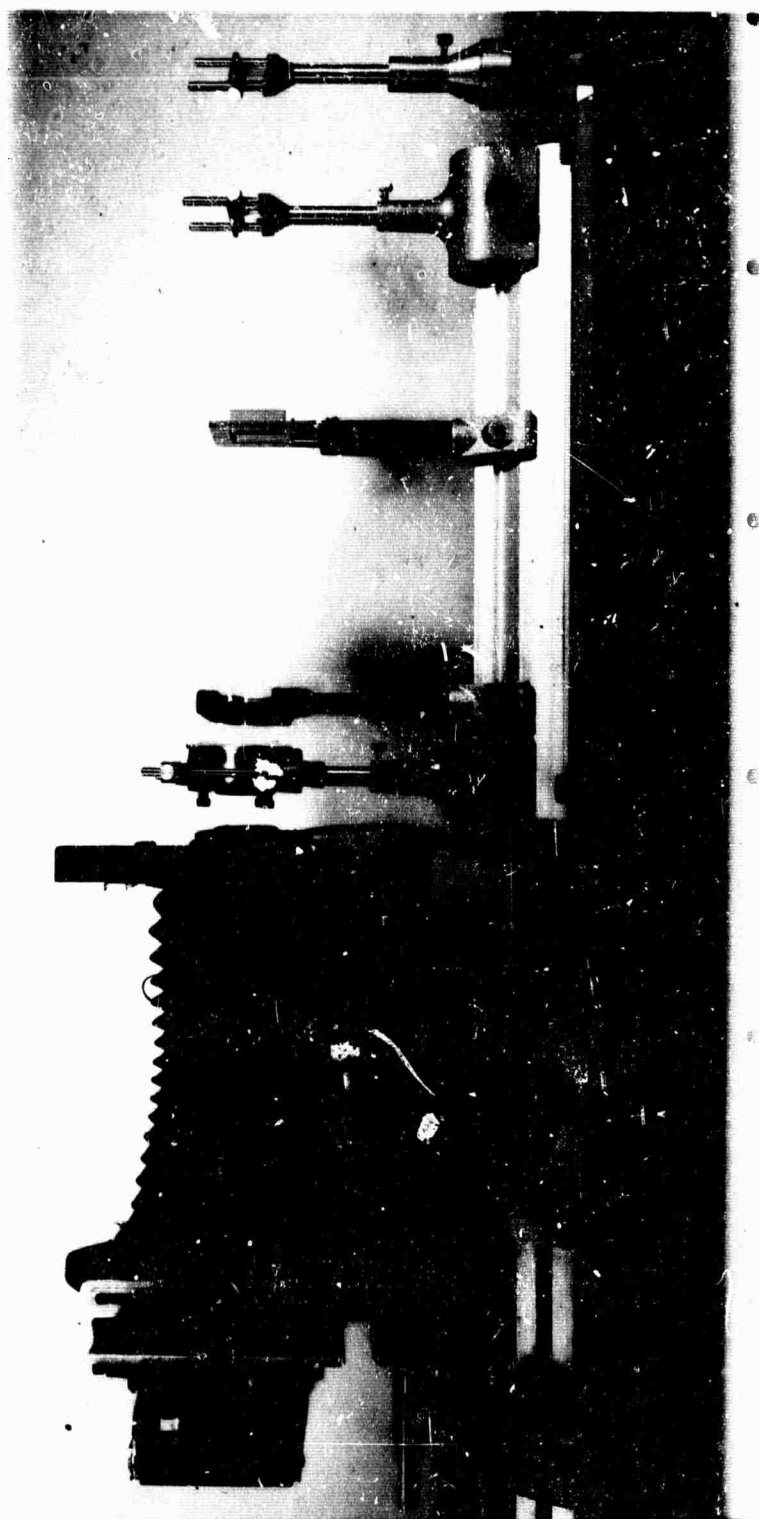
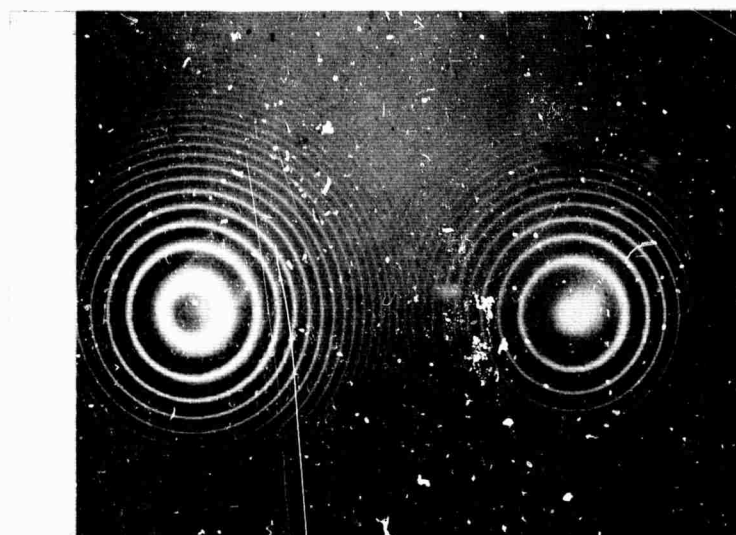


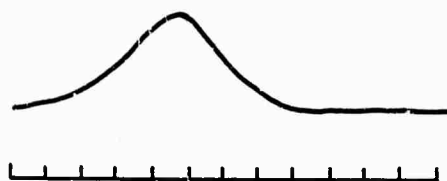
Figure 1. Wavelength Measuring System

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Etalon Spacing
5mm

Ruby He-Ne



Scale: 1 division = 10 nanoseconds

Figure 2. Typical Calibration Photo and Laser Shot

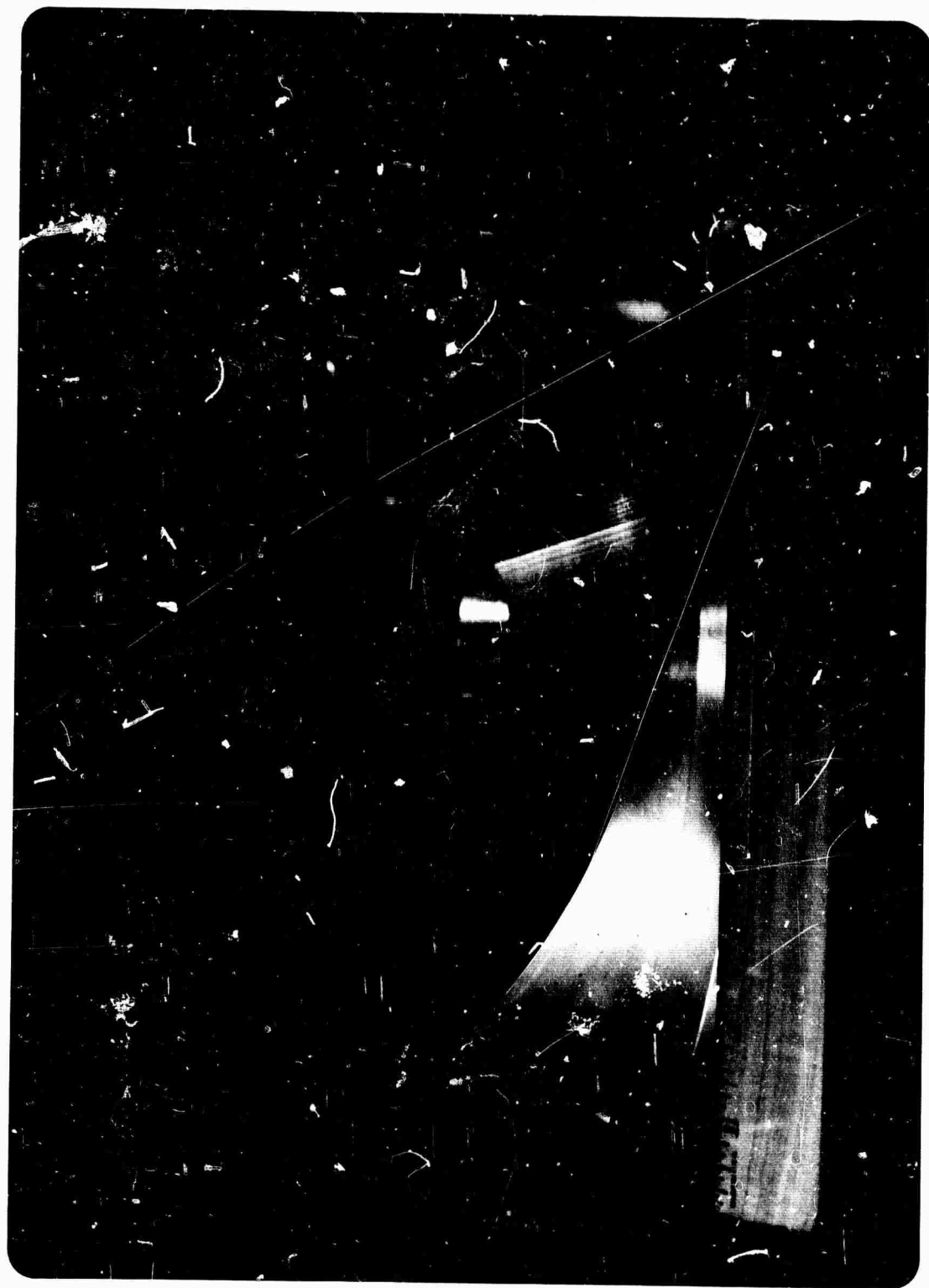


Figure 3. Cylindrical Parabola Sound Mirror

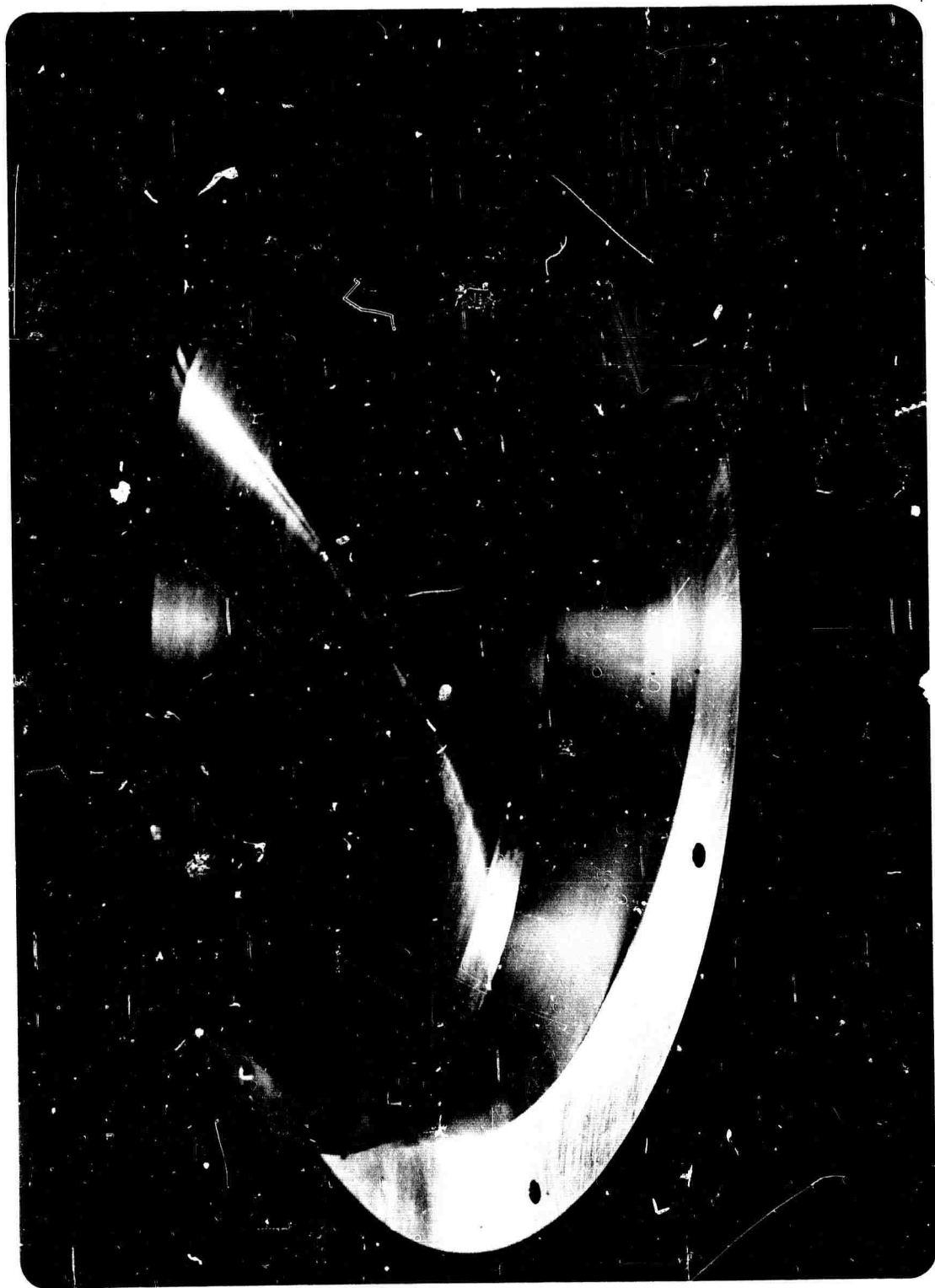


Figure 4. Paraboloidal Sound Mirror

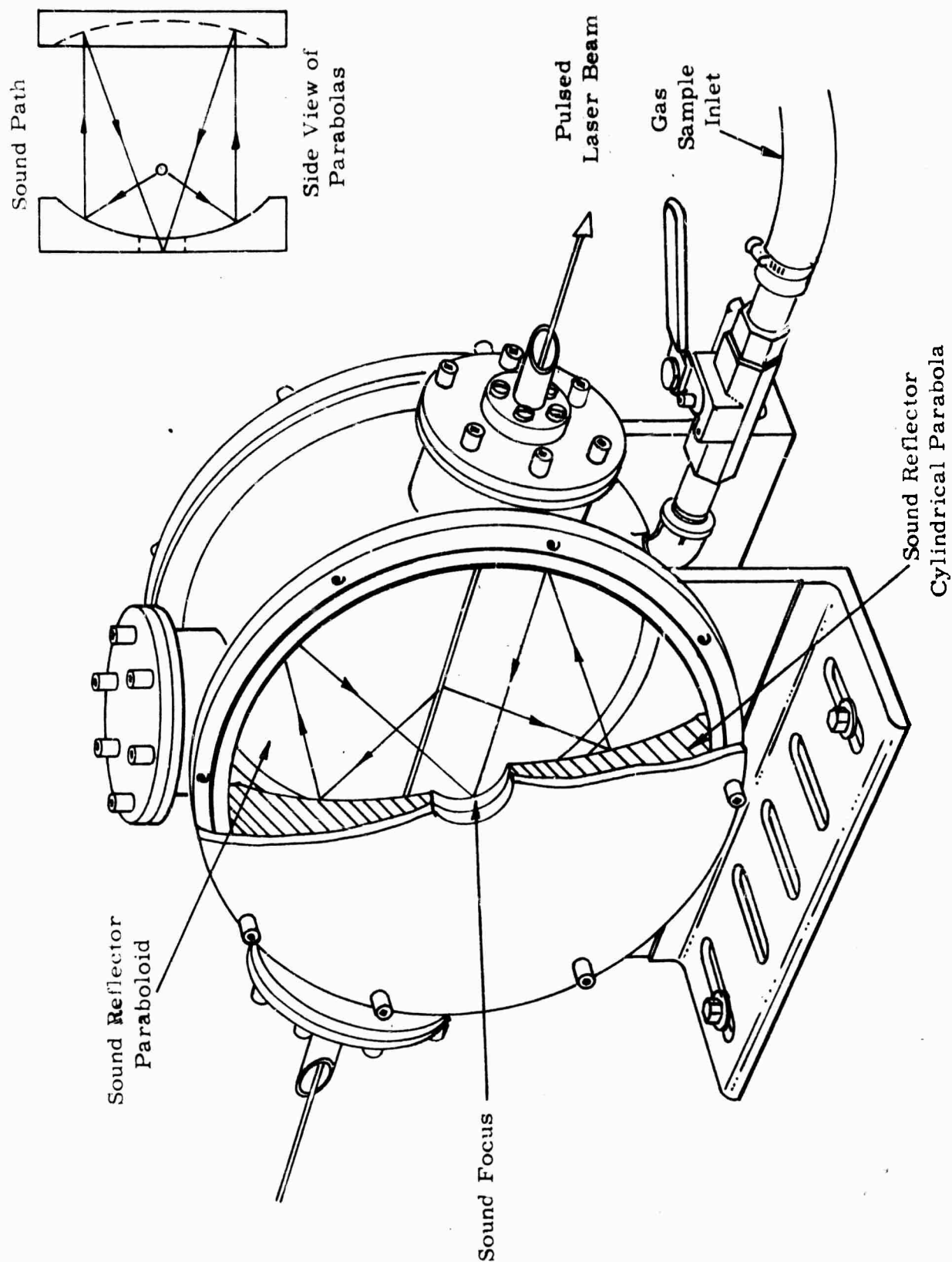
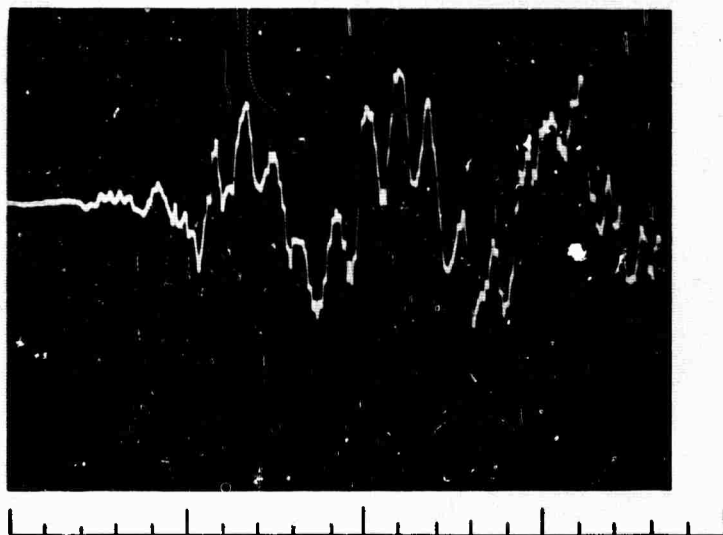


Figure 5. Acoustic Chamber



Time Scale: 1 division = 1 millisecond

Figure 6. Typical Response With 10k cps Microphone

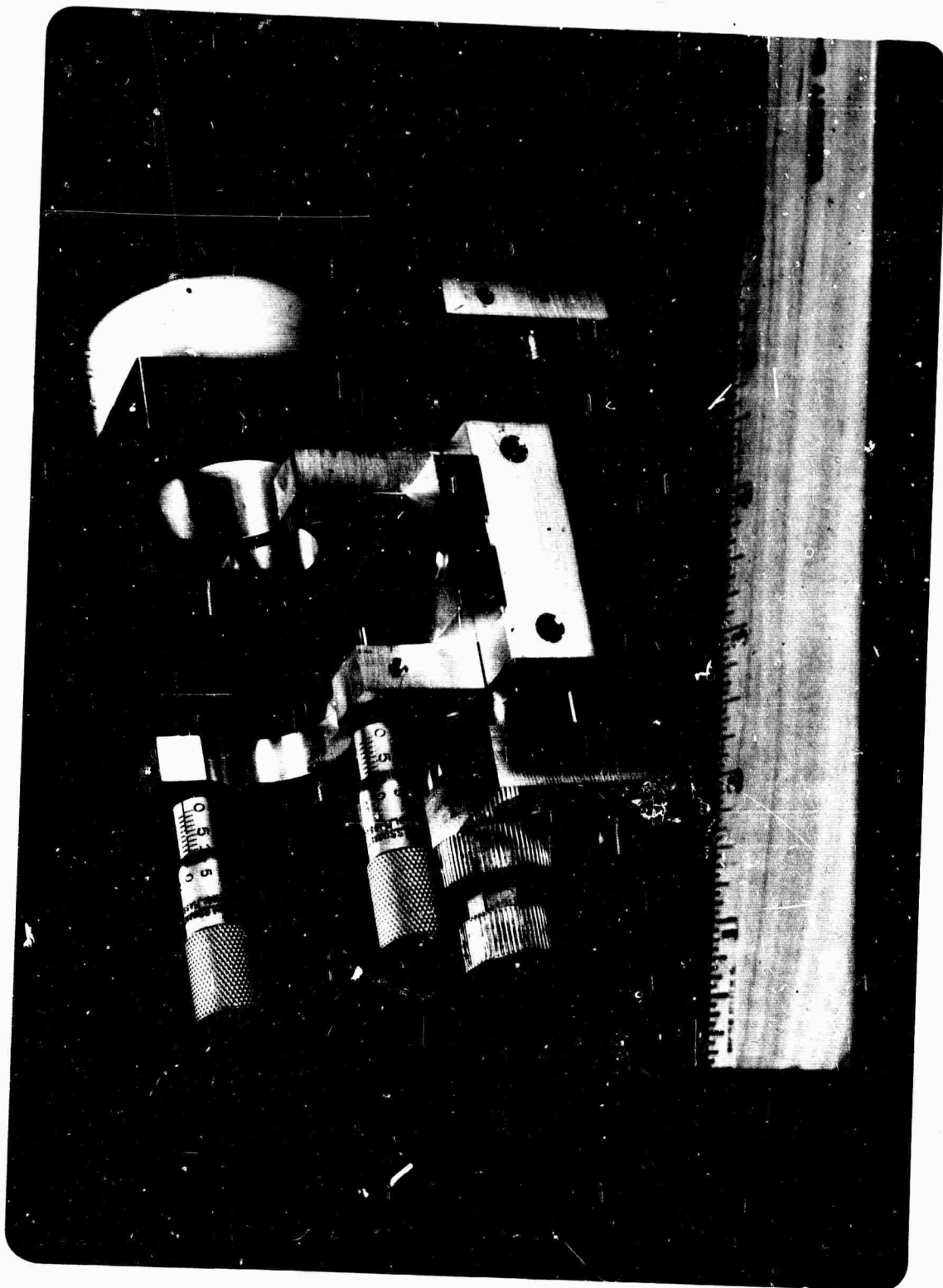


Figure 7. New Force Balance Microphone